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<p>(54) Title: FUSION PROTEINS CONTAINING N-TERMINAL FRAGMENTS OF HUMAN SERUM ALBUMIN</p> <p>(57) Abstract</p> <p>A fusion polypeptide comprising, as at least part of the N-terminal portion thereof, an N-terminal portion of HSA or a variant thereof and, as at least part of the C-terminal portion thereof, another polypeptide except that, when the said N-terminal portion of HSA is the 1-n portion where n is 369 to 419 or a variant thereof, then the said polypeptide is one of various specified entities, including the 585 to 1578 portion of human fibronectin or a variant thereof. The HSA-like portion may have additional N-terminal residues, such as secretion leader sequences (signal sequences). The C-terminal portion is preferably the 585-1578 portion of human plasma fibronectin. The N-terminal and C-terminal portions may be cleavable to yield the isolated C-terminal portion, with the N-terminal portion having served to facilitate secretion from the host.</p>		

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Fusion proteins containing N-terminal fragments of human serum albumin

The present invention relates to fusion polypeptides where two individual polypeptides or parts thereof are fused to form a single amino acid chain. Such fusion may arise from the expression of a single continuous coding sequence formed by recombinant DNA techniques.

Fusion polypeptides are known, for example those where a polypeptide which is the ultimately desired product of the process is expressed with an N-terminal "leader sequence" which encourages or allows secretion of the polypeptide from the cell. An example is disclosed in EP-A-116 201 (Chiron).

Human serum albumin (HSA) is a known protein found in the blood. EP-A-147 198 (Delta Biotechnology) discloses its expression in a transformed host, in this case yeast. Our earlier application EP-A-322 094 discloses N-terminal fragments of HSA, namely those consisting of residues 1-n where n is 369 to 419, which have therapeutic utility. The application also mentions the possibility of fusing the C-terminal residue of such molecules to other, unnamed, polypeptides.

One aspect of the present invention provides a fusion polypeptide comprising, as at least part of the N-terminal portion thereof, an N-terminal portion of HSA or a variant thereof and, as at least part of the C-terminal portion thereof, another polypeptide except that, when the said N-terminal portion of HSA is the 1-n portion where n is 369 to 419 or a variant thereof then the said polypeptide is (a) the 585 to 1578 portion of human fibronectin or a variant thereof, (b) the 1 to 368 portion of CD4 or a variant thereof, (c) platelet derived growth factor, or a variant thereof, (d) transforming growth factor, or a variant thereof, (e) the 1-261 portion of mature human plasma fibronectin or a variant thereof, (f) the 278-578 portion of mature human plasma fibronectin or a variant thereof, (g) the 1-272 portion of mature human von Willebrand's Factor or a variant thereof, or (h) alpha-1-antitrypsin or a variant thereof.

The N-terminal portion of HSA is preferably the said 1-n portion, the 1-177 portion (up to and including the cysteine), the 1-200 portion (up to but excluding the cysteine) or a portion intermediate 1-177 and 1-200.

The term "human serum albumin" (HSA) is intended to include (but not necessarily to be restricted to) known or yet-to-be-discovered polymorphic forms of HSA. For example, albumin Naskapi has Lys-372 in place of Glu-372 and pro-albumin Christchurch has an altered pro-sequence. The term "variants" is intended to include (but not necessarily to be restricted to) minor artificial variations in sequence (such as molecules lacking one or a few residues, having conservative substitutions or minor insertions of residues, or having minor variations of amino acid structure). Thus polypeptides which have 80%, preferably 85%, 90%, 95% or 99%, homology with HSA are deemed to be "variants". It is also preferred for such variants to be physiologically equivalent to HSA; that is to say, variants preferably share at least one pharmacological utility with HSA. Furthermore, any putative variant which is to be used pharmacologically should be non-immunogenic in the animal (especially human) being treated.

Conservative substitutions are those where one or more amino acids are substituted for others having similar properties such that one skilled in the art of polypeptide chemistry would expect at least the secondary structure, and preferably the tertiary structure, of the polypeptide to be substantially unchanged. For example, typical such

substitutions include asparagine for glutamine, serine for asparagine and arginine for lysine. Variants may alternatively, or as well, lack up to ten (preferably only one or two) intermediate amino acid residues (ie not at the termini of the said N-terminal portion of HSA) in comparison with the corresponding portion of natural HSA; preferably any such omissions occur in the 100 to 369 portion of the molecule (relative to mature HSA itself) (if present). Similarly, up to ten, but preferably only one or two, amino acids may be added, again in the 100 to 369 portion for preference (if present). The term "physiologically functional equivalents" also encompasses larger molecules comprising the said sequence plus a further sequence at the N-terminal (for example, pro-HSA, pre-pro-HSA and met-HSA).

Clearly, the said "another polypeptide" in the fusion compounds of the invention cannot be the remaining portion of HSA, since otherwise the whole polypeptide would be HSA, which would not then be a "fusion polypeptide".

Even when the HSA-like portion is not the said 1-n portion of HSA, it is preferred for the non-HSA portion to be one of the said (a) to (h) entities.

The 1 to 368 portion of CD4 represents the first four disulphide-linked immunoglobulin-like domains of the human T lymphocyte CD4 protein, the gene for and amino acid sequence of which are disclosed in D. Smith *et al* (1987) *Science* 328, 1704-1707. It is used to combat HIV infections.

The sequence of human platelet-derived growth factor (PDGF) is described in Collins *et al* (1985) *Nature* 316, 748-750. Similarly, the sequence of transforming growth factors β (TGF- β) is described in Derynck *et al* (1985) *Nature* 316, 701-705. These growth factors are useful for wound-healing.

A cDNA sequence for the 1-261 portion of Fn was disclosed in EP-A-207 751 (obtained from plasmid pFH6 with endonuclease PvuII). This portion binds fibrin and can be used to direct fused compounds to blood clots.

A cDNA sequence for the 278-578 portion of Fn, which contains a collagen-binding domain, was disclosed by R.J. Owens and F.E. Baralle in 1986 *E.M.B.O.J.* 5, 2825-2830. This portion will bind to platelets.

The 1-272 portion of von Willebrand's Factor binds and stabilises factor VIII. The sequence is given in Bontham et al, Nucl. Acids Res. 14, 7125-7127.

Variants of alpha-1-antitrypsin include those disclosed by Rosenberg et al (1984) Nature 312, 77-80. In particular, the present invention includes the Pittsburgh variant (Met³⁵⁸ is mutated to Arg) and the variant where Pro³⁵⁷ and Met³⁵⁸ are mutated to alanine and arginine respectively. These compounds are useful in the treatment of septic shock and lung disorders.

Variants of the non-HSA portion of the polypeptides of the invention include variations as discussed above in relation to the HSA portion, including those with conservative amino acid substitutions, and also homologues from other species.

The fusion polypeptides of the invention may have N-terminal amino acids which extend beyond the portion corresponding to the N-terminal portion of HSA. For example, if the HSA-like portion corresponds to an N-terminal portion of mature HSA, then pre-, pro-, or pre-pro sequences may be added thereto, for example the yeast alpha-factor leader sequence. The fused leader portions of WO 90/01063 may be used. The polypeptide which is

fused to the HSA portion may be a naturally-occurring polypeptide, a fragment thereof or a novel polypeptide, including a fusion polypeptide. For example, in Example 3 below, a fragment of fibronectin is fused to the HSA portion via a 4 amino acid linker.

It has been found that the amino terminal portion of the HSA molecule is so structured as to favour particularly efficient translocation and export of the fusion compounds of the invention in eukaryotic cells.

A second aspect of the invention provides a transformed host having a nucleotide sequence so arranged as to express a fusion polypeptide as described above. By "so arranged", we mean, for example, that the nucleotide sequence is in correct reading frame with an appropriate RNA polymerase binding site and translation start sequence and is under the control of a suitable promoter. The promoter may be homologous with or heterologous to the host. Downstream (3') regulatory sequences may be included if desired, as is known. The host is preferably yeast (for example Saccharomyces spp., e.g. S. cerevisiae; Kluyveromyces spp., e.g. K. lactis; Pichia spp.; or Schizosaccharomyces spp., e.g. S. pombe) but may be any

other suitable host such as E. coli, B. subtilis, Aspergillus spp., mammalian cells, plant cells or insect cells.

A third aspect of the invention provides a process for preparing a fusion polypeptide according to the first aspect of the invention by cultivation of a transformed host according to the second aspect of the invention, followed by separation of the fusion polypeptide in a useful form.

A fourth aspect of the invention provides therapeutic methods of treatment of the human or other animal body comprising administration of such a fusion polypeptide.

In the methods of the invention we are particularly concerned to improve the efficiency of secretion of useful therapeutic human proteins from yeast and have conceived the idea of fusing to amino-terminal portions of HSA those proteins which may ordinarily be only inefficiently secreted. One such protein is a potentially valuable wound-healing polypeptide representing amino acids 585 to 1578 of human fibronectin (referred to herein as Fn 585-1578). As we have described in a separate application (filed simultaneously herewith) this molecule contains cell spreading, chemotactic and chemokinetic activities

useful in healing wounds. The fusion polypeptides of the present invention wherein the C-terminal portion is Fn 585-1578 can be used for wound healing applications as biosynthesised, especially where the hybrid human protein will be topically applied. However, the portion representing amino acids 585 to 1578 of human fibronectin can if desired be recovered from the fusion protein by preceding the first amino acid of the fibronectin portion by amino acids comprising a factor X cleavage site. After isolation of the fusion protein from culture supernatant, the desired molecule is released by factor X cleavage and purified by suitable chromatography (e.g. ion-exchange chromatography). Other sites providing for enzymatic or chemical cleavage can be provided, either by appropriate juxtaposition of the N-terminal and C-terminal portions or by the insertion therebetween of an appropriate linker.

At least some of the fusion polypeptides of the invention, especially those including the said CD4 and vWF fragments, PDGF and α_1 AT, also have an increased half-life in the blood and therefore have advantages and therapeutic utilities themselves, namely the therapeutic utility of the non-HSA portion of the molecule. In the case of α_1 AT and others, the compound will normally be administered as

a one-off dose or only a few doses over a short period, rather than over a long period, and therefore the compounds are less likely to cause an immune response.

EXAMPLES : SUMMARY

Standard recombinant DNA procedures were as described by Maniatis et al (1982 and recent 2nd edition) unless otherwise stated. Construction and analysis of phage M13 recombinant clones was as described by Messing (1983) and Sanger et al (1977).

DNA sequences encoding portions of human serum albumin used in the construction of the following molecules are derived from the plasmids mHOB12 and pDBD2 (EP-A-322 094, Delta Biotechnology Ltd, relevant portions of which are reproduced below) or by synthesis of oligonucleotides equivalent to parts of this sequence. DNA sequences encoding portions of human fibronectin are derived from the plasmid pFHDEL1, or by synthesis of oligonucleotides equivalent to parts of this sequence. Plasmid pFHDEL1, which contains the complete human cDNA encoding plasma fibronectin, was obtained by ligation of DNA derived from plasmids pFH6, 16, 54, 154 and 1 (EP-A-207 751; Delta Biotechnology Ltd).

This DNA represents an mRNA variant which does not contain the 'ED' sequence and had an 89-amino acid variant of the III-CS region (R.J. Owens, A.R. Kornblihtt and F.E. Baralle (1986) Oxford Surveys on Eukaryotic Genes 3 141-160). The map of this vector is disclosed in Fig. 11 and the protein sequence of the mature polypeptide produced by expression of this cDNA is shown in Fig. 5.

Oligonucleotides were synthesised on an Applied Biosystems 380B oligonucleotide synthesiser according to the manufacturer's recommendations (Applied Biosystems, Warrington, Cheshire, UK).

An expression vector was constructed in which DNA encoding the HSA secretion signal and mature HSA up to and including the 387th amino acid, leucine, fused in frame to DNA encoding a segment of human fibronectin representing amino acids 585 to 1578 inclusive, was placed downstream of the hybrid promoter of EP-A-258 067 (Delta Biotechnology), which is a highly efficient galactose-inducible promoter functional in Saccharomyces cerevisiae. The codon for the 1578th amino acid of human fibronectin was directly followed by a stop codon (TAA) and then the S. cerevisiae phosphoglycerate kinase (PGK) gene transcription terminator. This vector was then introduced into S. cerevisiae by transformation, wherein it directed

the expression and secretion from the cells of a hybrid molecule representing the N-terminal 387 amino acids of HSA C-terminally fused to amino acids 585 to 1578 of human fibronectin.

In a second example a similar vector is constructed so as to enable secretion by S. cerevisiae of a hybrid molecule representing the N-terminal 195 amino acids of HSA C-terminally fused to amino acids 585 to 1578 of human fibronectin.

Aspects of the present invention will now be described by way of example and with reference to the accompanying drawings, in which:

Figure 1 (on two sheets) depicts the amino acid sequence currently thought to be the most representative of natural HSA, with (boxed) the alternative C-termini of HSA(1-n);

Figure 2 (on two sheets) depicts the DNA sequence coding for mature HSA, wherein the sequence included in Linker 3 is underlined;

Figure 3 illustrates, diagrammatically, the construction of mHOB16;

Figure 4 illustrates, diagrammatically, the construction of pHOB31;

Figure 5 (on 6 sheets) illustrates the mature protein sequence encoded by the Fn plasmid pFHDEL1;

Figure 6 illustrates Linker 5, showing the eight constituent oligonucleotides;

Figure 7 shows schematically the construction of plasmid pDBDF2;

Figure 8 shows schematically the construction of plasmid pDBDF5;

Figure 9 shows schematically the construction of plasmid pDBDF9;

Figure 10 shows schematically the construction of plasmid DBDF12, using plasmid pFHDEL1; and

Figure 11 shows a map of plasmid pFHDEL1.

EXAMPLE 1 : HSA 1-387 FUSED TO Fn 585-1578

The following is an account of a preparation of plasmids comprising sequences encoding a portion of HSA, as is disclosed in EP-A-322 094.

The human serum albumin coding sequence used in the construction of the following molecules is derived from the plasmid M13mp19.7 (EP-A-201 239, Delta Biotechnology Ltd.) or by synthesis of oligonucleotides equivalent to parts of this sequence. Oligonucleotides were synthesised using phosphoramidite chemistry on an Applied Biosystems 380B oligonucleotide synthesizer according to the manufacturer's recommendations (AB Inc., Warrington, Cheshire, England).

An oligonucleotide was synthesised (Linker A) which represented a part of the known HSA coding sequence (Figure 2) from the PstI site (1235-1240, Figure 2) to the codon for valine 381 wherein that codon was changed from GTG to GTC:

15

Linker 1

	D	P	H	E	C	Y
5'	GAT	CCT	CAT	GAA	TGC	TAT
3' ACGT	CTA	GGA	GTA	CTT	ACG	ATA

1247

A	K	V	F	D	E	F	K
GCC	AAA	GTG	TTC	GAT	GAA	TTT	AAA
CGG	TTT	CAC	AAG	CTA	CTT	AAA	TTT

1267

P	L	V
CTT	GTC	3'
GGA	CAG	5'

Linker 1 was ligated into the vector M13mp19 (Norranders et al, 1983) which had been digested with PstI and HincII and the ligation mixture was used to transfect E.coli strain XL1-Blue (Stratagene Cloning Systems, San Diego, CA). Recombinant clones were identified by their failure to evolve a blue colour on medium containing the chromogenic indicator X-gal (5-bromo-4-chloro-3-indolyl- β -D-galactoside) in the presence of IPTG (isopropylthio- β -galactoside). DNA sequence analysis of template DNA prepared from bacteriophage particles of recombinant clones identified a molecule with the required DNA sequence, designated mHOB12 (Figure 3).

M13mp19.7 consists of the coding region of mature HSA in M13mp19 (Norrrander et al, 1983) such that the codon for the first amino acid of HSA, GAT, overlaps a unique XhoI site thus:

	Asp	Ala	
5'	C T C G A G A T G C A		3'
3'	G A G C T C T A C G T		5'
	<u>XhoI</u>		

(EP-A-210 239). M13mp19.7 was digested with XhoI and made flush-ended by S1-nuclease treatment and was then ligated with the following oligonucleotide (Linker 2):

Linker 2

5'	T C T T T T A T C C A A G C T T G G A T A A A A G A	3'
3'	A G A A A A T A G G T T C G A A C C T A T T T T C T	5'
	<u>HindIII</u>	

The ligation mix was then used to transfect E.coli XL1-Blue and template DNA was prepared from several plaques and then analysed by DNA sequencing to identify a clone, pDBD1 (Figure 4), with the correct sequence.

A 1.1 kb HindIII to PstI fragment representing the 5' end of the HSA coding region and one half of the inserted oligonucleotide linker was isolated from pBBD1 by agarose gel electrophoresis. This fragment was then ligated with double stranded mHOB12 previously digested with HindIII and PstI and the ligation mix was then used to transfect E.coli XL1-Blue. Single stranded template DNA was prepared from mature bacteriophage particles of several plaques. The DNA was made double stranded in vitro by extension from annealed sequencing primer with the Klenow fragment of DNA polymerase I in the presence of deoxynucleoside triphosphates. Restriction enzyme analysis of this DNA permitted the identification of a clone with the correct configuration, mHOB15 (Figure 4).

The following oligonucleotide (Linker 3) represents from the codon for the 382nd amino acid of mature HSA (glutamate, GAA) to the codon for lysine 389 which is followed by a stop codon (TAA) and a HindIII site and then a BamHI cohesive end:

Linker 3

	E	E	P	Q	N	L	I	K	J		
5'	GAA	GAG	CCT	CAG	AAT	TTA	ATC	AAA	TAA	GCTTG	3'
3'	CTT	CTC	GGA	GTC	TTA	AAT	TAG	TTT	ATT	CGAACCTAG	5'

This was ligated into double stranded mHOB15, previously digested with HincII and BamHI. After ligation, the DNA was digested with HincII to destroy all non-recombinant molecules and then used to transfect E.coli XL1-Blue. Single stranded DNA was prepared from bacteriophage particles of a number of clones and subjected to DNA sequence analysis. One clone having the correct DNA sequence was designated mHOB16 (Figure 4).

A molecule in which the mature HSA coding region was fused to the HSA secretion signal was created by insertion of Linker 4 into BamHI and XhoI digested M13mp19.7 to form pDBD2 (Figure 4).

Linker 4

	M	K	W	V	S	F	
5' GATCC	ATG	AAG	TGG	GTA	AGC	TTT	
	G TAC	TTC	ACC	CAT	TCG	AAA	
I	S	L	L	F	L	F	S
ATT	TCC	CTT	CTT	TTT	CTC	TTT	AGC
TAA	AGG	GAA	GAA	AAA	GAG	AAA	TCG

S	A	Y	S	R	G	V	F
TCG	GCT	TAT	TCC	AGG	GGT	GTG	TTT
AGC	CGA	ATA	AGG	TCC	CCA	CAC	AAA

R R
CG 3'
GCAGCT 5'

In this linker the codon for the fourth amino acid after the initial methionine, ACC for threonine in the HSA pre-pro leader sequence (Lawn *et al.*, 1981), has been changed to AGC for serine to create a HindIII site.

A sequence of synthetic DNA representing a part of the known HSA coding sequence (Lawn *et al.*, 1981) (amino acids 382 to 387, Fig. 2), fused to part of the known fibronectin coding sequence (Kornblihtt *et al.*, 1985) (amino acids 585 to 640, Fig. 2), was prepared by synthesising six oligonucleotides (Linker 5, Fig. 6). The oligonucleotides 2, 3, 4, 6, 7 and 8 were phosphorylated using T4 polynucleotide kinase and then the oligonucleotides were annealed under standard conditions in pairs, i.e. 1+8, 2+7, 3+6 and 4+5. The annealed oligonucleotides were then mixed together and ligated with mHOB12 which had previously been digested with the restriction enzymes HincII and EcoRI. The ligation

mixture was then used to transfect E.coli XLI-Blue (Stratagene Cloning Systems, San Diego, CA). Single stranded template DNA was then prepared from mature bacteriophage particles derived from several independent plaques and then was analysed by DNA sequencing. A clone in which a linker of the expected sequence had been correctly inserted into the vector was designated pDBDF1 (Fig. 7). This plasmid was then digested with PstI and EcoRI and the approx. 0.24kb fragment was purified and then ligated with the 1.29kb BamHI-PstI fragment of pDBD2 (Fig. 7) and BamHI + EcoRI digested pUC19 (Yanisch-Perron, et al., 1985) to form pDBDF2 (Fig. 7).

A plasmid containing a DNA sequence encoding full length human fibronectin, pFHDEL1, was digested with EcoRI and XhoI and a 0.77kb EcoRI-XhoI fragment (Fig. 8) was isolated and then ligated with EcoRI and SalI digested M13 mp18 (Norrander et al., 1983) to form pDBDF3 (Fig. 8).

The following oligonucleotide linker (Linker 6) was synthesised, representing from the PstI site at 4784-4791 of the fibronectin sequence of EP-A-207 751 to the codon for tyrosine 1578 (Fig. 5) which is followed by a stop codon (TAA), a HindIII site and then a BamHI cohesive end:

Linker 6

G P D Q T E M T I E G L
 GGT CCA GAT CAA ACA GAA ATG ACT ATT GAA GGC TTG
 A CGT CCA GGT CTA GTT TGT CTT TAC TGA TAA CTT CCG AAC

Q P T V E Y Stop
 CAG CCC ACA GTG GAG TAT TAA GCTTG
 GTC GGG TGT CAC CTC ATA ATT CGAACCTAG

This linker was then ligated with PstI and HindIII digested pDBDF3 to form pDBDF4 (Fig. 8). The following DNA fragments were then ligated together with BglII digested pKV50 (EP-A-258 067) as shown in Fig. 8: 0.68kb EcoRI-BamHI fragment of pDBDF4, 1.5kb BamHI-StuI fragment of pDBDF2 and the 2.2kb StuI-EcoRI fragment of pFHDEL1. The resultant plasmid pDBDF5 (Fig. 8) includes the promoter of EP-A-258 067 to direct the expression of the HSA secretion signal fused to DNA encoding amino acids 1-387 of mature HSA, in turn fused directly and in frame with DNA encoding amino acids 585-1578 of human fibronectin, after which translation would terminate at the stop codon TAA. This is then followed by the S.cerevisiae PGK gene transcription terminator. The

plasmid also contains sequences which permit selection and maintenance in Escherichia coli and S.cerevisiae (EP-A-258 067).

This plasmid was introduced into S.cerevisiae S150-2B (leu2-3 leu2-112 ura3-52 trp1-289 his3- 1) by standard procedures (Beggs, 1978). Transformants were subsequently analysed and found to produce the HSA-fibronectin fusion protein.

EXAMPLE 2 : HSA 1-195 FUSED TO Fn 585-1578

In this second example the first domain of human serum albumin (amino acids 1-195) is fused to amino acids 585-1578 of human fibronectin.

The plasmid pDBD2 was digested with BamHI and BglII and the 0.79kb fragment was purified and then ligated with BamHI-digested M13mp19 to form pDBDF6 (Fig. 6). The following oligonucleotide:

5'-C C A A A G C T C G A G G A A C T T C G-3'

was used as a mutagenic primer to create a XhoI site in pDBDF6 by in vitro mutagenesis using a kit supplied by Amersham International PLC. This site was created by

changing base number 696 of HSA from a T to a G (Fig. 2). The plasmid thus formed was designated pDBDF7 (Fig. 9). The following linker was then synthesised to represent from this newly created XhoI site to the codon for lysine 195 of HSA (AAA) and then from the codon for isoleucine 585 of fibronectin to the ends of oligonucleotides 1 and 8 shown in Fig. 6.

Linker 7

```
      D   E   L   R   D   E   G   K   A   S   S   A   K
TC GAT GAA CTT CGG GAT GAA GGG AAG GCT TCG TCT GCC AAA
      A CTT GAA GCC CTA CTT CCC TTC CGA AGC AGA CGG TTT

      I   T   E   T   P   S   Q   P   N   S   H
ATC ACT GAG ACT CCG AGT CAG C
      TAG TGA CTC TGA GGC TCA GTC GGG TTG AGG GTG G
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This linker was ligated with the annealed oligonucleotides shown in Fig. 3, i.e. 2+7, 3+6 and 4+5 together with XhoI and EcoRI digested pDBDF7 to form pDBDF8 (Fig. 9). Note that in order to recreate the original HSA DNA sequence, and hence amino acid sequence, insertion of linker 7 and the other oligonucleotides into pDBDF7 does not recreate the XhoI site.

The 0.83kb BamHI-StuI fragment of pDBDF8 was purified and then was ligated with the 0.68kb EcoRI-BamHI fragment of pDBDF2 and the 2.22kb StuI-EcoRI fragment of pFHDEL1 into BglII-digested pKV50 to form pDBDF9 (Fig. 9). This plasmid is similar to pDBDF5 except that it specifies only residues 1-195 of HSA rather than 1-387 as in pDBDF5.

When introduced into S.cerevisiae S150-2B as above, the plasmid directed the expression and secretion of a hybrid molecule composed of residues 1-195 of HSA fused to residues 585-1578 of fibronectin.

EXAMPLE 3 : HSA 1-387 FUSED TO Fn 585-1578, AS CLEAVABLE MOLECULE

In order to facilitate production of large amounts of residues 585-1578 of fibronectin, a construct was made in which DNA encoding residues 1-387 of HSA was separated from DNA encoding residues 585-1578 of fibronectin by the sequence

I E G R
ATT GAA GGT AGA
TAA CTT CCA TCT

which specifies the cleavage recognition site for the blood clotting Factor X. Consequently the purified secreted product can be treated with Factor X and then the fibronectin part of the molecule can be separated from the HSA part.

To do this two oligonucleotides were synthesised and then annealed to form Linker 8.

Linker 8

E	E	P	Q	N	L	I	E	G
GAA	GAG	CCT	CAG	AAT	TTA	ATT	GAA	GGT
CTT	CTC	GGA	GTC	TTA	AAT	TAA	CTT	CCA

R	I	T	E	T	P	S	Q	P
AGA	ATC	ACT	GAG	ACT	CCG	AGT	CAG	C
TCT	TAG	TGA	CTC	TGA	GGC	TCA	GTC	GGG

N S H

TTG AGG GTG G

This linker was then ligated with the annealed oligonucleotides shown in Fig. 6, i.e. 2+7, 3+6 and 4+5 into HincII and EcoRI digested mHOB12, to form pDBDF10

(Fig. 7). The plasmid was then digested with PstI and EcoRI and the roughly 0.24kb fragment was purified and then ligated with the 1.29kb BamHI-PstI fragment of pDBD2 and BamHI and EcoRI digested pUC19 to form pDBDF11 (Fig. 10).

The 1.5kb BamHI-StuI fragment of pDBDF11 was then ligated with the 0.68kb EcoRI-BamHI fragment of pDBDF4 and the 2.22kb StuI-EcoRI fragment of pFHDEL1 into BglII-digested pKV50 to form pDBDF12 (Fig. 10). This plasmid was then introduced into S.cerevisiae S150-2B. The purified secreted fusion protein was treated with Factor X to liberate the fibronectin fragment representing residues 585-1578 of the native molecule.

REFERENCES

Beggs, J.D. (1978) Nature 275, 104-109

Kornblihtt et al. (1985) EMBO J. 4, 1755-1759

Lawn, R.M. et al. (1981) Nucl. Acid. Res. 9, 6103-6114

Maniatis, T. et al. (1982) Molecular cloning: A laboratory manual. Cold Spring Harbor Laboratory, Cold Spring Harbor, New York.

Messing, J. (1983) Methods Enzymol. 101, 20-78

Norlander, J. et al. (1983) Gene 26, 101-106

Sanger, F. et al. (1977) Proc. Natl. Acad. Sci. USA 74, 5463-5467

Yanisch-Perron, C. (1985) Gene 33, 103-119

CLAIMS

1. A fusion polypeptide comprising, as at least part of the N-terminal portion thereof, an N-terminal portion of HSA or a variant thereof and, as at least part of the C-terminal portion thereof, another polypeptide except that, when the said N-terminal portion of HSA is the 1-n portion where n is 369 to 419 or a variant thereof then the said polypeptide is (a) the 585 to 1578 portion of human fibronectin or a variant thereof, (b) the 1 to 368 portion of CD4 or a variant thereof, (c) platelet derived growth factor or a variant thereof, (d) transforming growth factor β or a variant thereof, (e) the 1-261 portion of mature human plasma fibronectin or a variant thereof, (f) the 278-578 portion of mature human plasma fibronectin or a variant thereof, (g) the 1-272 portion of mature human von Willebrand's Factor or a variant thereof, or (h) alpha-1-antitrypsin or a variant thereof.

2. A fusion polypeptide according to Claim 1 additionally comprising at least one N-terminal amino acid extending beyond the portion corresponding to the N-terminal portion of HSA.
3. A fusion polypeptide according to Claim 1 or 2 wherein there is a cleavable region at the junction of the said N-terminal or C-terminal portions.
4. A fusion polypeptide according to any one of the preceding claims wherein the said C-terminal portion is the 585 to 1578 portion of human plasma fibronectin or a variant thereof.
5. A transformed or transfected host having a nucleotide sequence so arranged as to express a fusion polypeptide according to any one of the preceding claims.
6. A process for preparing a fusion polypeptide by cultivation of a host according to Claim 5, followed by separation of the fusion polypeptide in a useful form.
7. A fusion polypeptide according to any one of Claims 1 to 4 for use in therapy.

FIGURE 1

10	20
Asp Ala His Lys Ser Glu Val Ala His Arg Phe Lys Asp Leu Gly Glu Glu Asn Phe Lys	
30	40
Ala Leu Val Leu Ile Ala Phe Ala Gln Tyr Leu Gln Gln Cys Pro Phe Glu Asp His Val	
50	60
Lys Leu Val Asn Glu Val Thr Glu Phe Ala Lys Thr Cys Val Ala Asp Glu Ser Ala Glu	
70	80
Asn Cys Asp Lys Ser Leu His Thr Leu Phe Gly Asp Lys Leu Cys Thr Val Ala Thr Leu	
90	100
Arg Glu Thr Tyr Gly Glu Met Ala Asp Cys Cys Ala Lys Gln Glu Pro Glu Arg Asn Glu	
110	120
Cys Phe Leu Gln His Lys Asp Asp Asn Pro Asn Leu Pro Arg Leu Val Arg Pro Glu Val	
130	140
Asp Val Met Cys Thr Ala Phe His Asp Asn Glu Glu Thr Phe Leu Lys Lys Tyr Leu Tyr	
150	160
Glu Ile Ala Arg Arg His Pro Tyr Phe Tyr Ala Pro Glu Leu Leu Phe Phe Ala Lys Arg	
170	180
Tyr Lys Ala Ala Phe Thr Glu Cys Cys Gln Ala Ala Asp Lys Ala Ala Cys Leu Leu Pro	
190	200
Lys Leu Asp Glu Leu Arg Asp Glu Gly Lys Ala Ser Ser Ala Lys Gln Arg Leu Lys Cys	
210	220
Ala Ser Leu Gln Lys Phe Gly Glu Arg Ala Phe Lys Ala Trp Ala Val Ala Arg Leu Ser	
230	240
Gln Arg Phe Pro Lys Ala Glu Phe Ala Glu Val Ser Lys Leu Val Thr Asp Leu Thr Lys	
250	260
Val His Thr Glu Cys Cys His Gly Asp Leu Leu Glu Cys Ala Asp Asp Arg Ala Asp Leu	
270	280
Ala Lys Tyr Ile Cys Glu Asn Gln Asp Ser Ile Ser Ser Lys Leu Lys Glu Cys Cys Glu	
290	300
Lys Pro Leu Leu Glu Lys Ser His Cys Ile Ala Glu Val Glu Asn Asp Glu Met Pro Ala	
310	320
Asp Leu Pro Ser Leu Ala Ala Asp Phe Val Glu Ser Lys Asp Val Cys Lys Asn Tyr Ala	
330	340
Glu Ala Lys Asp Val Phe Leu Gly Met Phe Leu Tyr Glu Tyr Ala Arg Arg His Pro Asp	
350	360
Tyr Ser Val Val Leu Leu Leu Arg Leu Ala Lys Thr Tyr Glu Thr Thr Leu Glu Lys Cys	
370	380
Cys Ala Ala Ala Asp Pro His Glu Cys Tyr Ala Lys Val Phe Asp Glu Phe Lys Pro Leu	

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FIGURE 1 Cont.

	390	400
Val Glu Glu Pro Gln Asn Leu Ile Lys Gln Asn Cys Glu Leu Phe Gln Gln Leu Gly Glu		
	410	420
Tyr Lys Phe Gln Asn Ala Leu Leu Val Arg Tyr Thr Lys Lys Val Pro Gln Val Ser		Thr
	430	440
Pro Thr Leu Val Glu Val Ser Arg Asn Leu Gly Lys Val Gly Ser Lys Cys Cys Lys His		
	450	460
Pro Glu Ala Lys Arg Met Pro Cys Ala Glu Asp Tyr Leu Ser Val Val Leu Asn Gln Leu		
	470	480
Cys Val Leu His Glu Lys Thr Pro Val Ser Asp Arg Val Thr Lys Cys Cys Thr Glu Ser		
	490	500
Leu Val Asn Arg Arg Pro Cys Phe Ser Ala Leu Glu Val Asp Glu Thr Tyr Val Pro Lys		
	510	520
Glu Phe Asn Ala Glu Thr Phe Thr Phe His Ala Asp Ile Cys Thr Leu Ser Glu Lys Glu		
	530	540
Arg Gln Ile Lys Lys Gln Thr Ala Leu Val Glu Leu Val Lys His Lys Pro Lys Ala Thr		
	550	560
Lys Glu Gln Leu Lys Ala Val Met Asp Asp Phe Ala Ala Phe Val Glu Lys Cys Cys Lys		
	570	580
Ala Asp Asp Lys Glu Thr Cys Phe Ala Glu Glu Gly Lys Lys Leu Val Ala Ala Ser Gln		
Ala Ala Leu Gly Leu		

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FIGURE 2 DNA sequence coding for mature HSA

10 20 30 40 50 60 70 80
GATGCACACAAGAGTGAAGCTTGCTCATCGGTTTAAAGATTTGGGAGAAGAAAATTCAGAGCGTTGGTGTGATTGCGCTT
D A H K S E V A H R F K D L G E E N F K A L V L I A F

90 100 110 120 130 140 150 160
TGCTCAGTATCTTCAGCAGTGTCCATTTGAAGATCATGTAAAATTAGTGAATGAAGTAACTGAATTTGCAAAAAACATGTC
A Q Y L Q Q C P F E D H V K L V N E V T E F A K T C

170 180 190 200 210 220 230 240
TTGCTGATGAGTCAGCTGAAAATTGTGACAAATCACTTCATACCGTTTTTGGAGACAAATATGCACAGTTGCCACTCTT
V A D E S A E N C D K S L H T L F G D K L C T V A T L

250 260 270 280 290 300 310 320
CGTGAACCTATGGTGAATGGCTGACTGCTGTGCAAAACAAGAACCTGAGAGAAATGAATGCTTTTSCAACACAAAGA
R E T Y G E M A D C C A K Q E P E R N E C F L Q H K D

330 340 350 360 370 380 390 400
TGACAAACCAACCTCCCGCGATTGGTGAGACAGAGGTTGATGTGATGTGCACTGCTTTTCATGACAAATGAAGAGACAT
D N P N L P R L V R P E V D V H C T A F H D N E E T

410 420 430 440 450 460 470 480
TTTTGAAAAATACCTTATATGAATTTGCCAGAAGACATGCTTACTTTTATGCCCGGAACTGCTTTTCTTTGCTAAAAGG
F L K X Y L Y E I A R R H P Y F Y A P E L L F F A K R

490 500 510 520 530 540 550 560
TATAAAGCTGCTTTTACAGAATGTTGCCAAGCTGCTGATAAAGCTGCTGCTGTTGCCAAAGCTGATGAAGCTTGGGGA
Y K A A F T E C C Q A A D K A A C L L P K L D E L R D

570 580 590 600 610 620 630 640
TGAAGGGAAGGCTTCTGCTGCGCAACAGAGACTCAATGTGCCAGTCTCCAAAAATTTGGAGAAAGAGCTTTCAAAGCAT
E G K A S S A K Q R L K C A S L Q K F G E R A F K A

650 660 670 680 690 700 710 720
GGGCAGTGGCTCGCTGAGCCAGAGATTTCCCAAAGCTGAGTTTGCAGAAGTTTCCAAAGTTAGTGACAGATCTTACCAAA
W A V A R L S Q R F P K A E F A E V S K L V T D L T K

730 740 750 760 770 780 790 800
GTCCACACGGAATGCTGCCATGGAGATCTGCTTGAATGTGCTGATGACAGGGCGGACCTTGCCTAAGTATATCTGTGAAAA
V H T E C C H G D L L E C A D D R A D L A K Y I C E N

810 820 830 840 850 860 870 880
TCAGGATTCGATCTCCAGTAACTGAAGGAATGCTGTGAAAAACCTCTGTTGGAAAAATCCCACTGCATTGCCGAAGTGG
Q D S I S S K L K E C C E K P L L E K S H C I A E V

890 900 910 920 930 940 950 960
AAAATGATGAGATGCTGCTGACTTGCCTTCATTAGCTGCTGATTTTGTGAAAGTAAGGATGTTTGCAAAAACTATGCT
E N D E M P A D L P S L A A D F V E S K D V C K N Y A

970 980 990 1000 1010 1020 1030 1040
GAGGCAAGGATGCTTCTGCTGGGCAATGTTTTGTATGAATATGCAAGAAGGCATCTGATTACTCTGCTGCTGCTGCTGCT
E A K D V F L G H F L Y E Y A R R H P D Y S V V L L L

FIGURE 2 Cont.

1050 1060 1070 1080 1090 1100 1110 1120
GAGACTTCCCAAGACATATGAAAACCACTCTAGAGAAAGTGGTGTGCCGCTGCAGATCCCTCATGAATGCTATGCCAAAGTGT
R L A K T Y E T T L E K C C A A A D P H E C Y A K V

1130 1140 1150 1160 1170 1180 1190 1200
TCGATGAATTTAAACCTCTGTGGAAAGAGCCTCAGAAATTTAATCAAAACAAAAGTGTGAGCTTTTTGAGCAGCTTGGAGAG
F D E F K P L V E E P Q N L E K Q N C E L F E Q L G E

1210 1220 1230 1240 1250 1260 1270 1280
TACAAATCCAGAAATGCGCTATTAGTTCTTACACCAAGAAAGTACCCCAAGTGTCAACTCCAACTCTGTAGAGGTCTC
Y K F Q N A L L V R Y T K K V P Q V S T P T L V E V S

1290 1300 1310 1320 1330 1340 1350 1360
AAGAAACCTAGGAAAAGTGGGCGCAATGTTGTAAACATCCTGAAGCAAAAAGAAATGCCCTGTGCAGAAAGACTATCTAT
R N L G K V G S K C C K R P E A K R M P C A E D Y L

1370 1380 1390 1400 1410 1420 1430 1440
CCGTGGTCCCTGAACCAAGTTATGTGTGTGCATGAGAAAACGCCAGTAAGTGACAGAGTCACAAATGCTGCACAGAGTCC
S V V L N Q L C V L H E K T P V S D R V T K C C T E S

1450 1460 1470 1480 1490 1500 1510 1520
TTGGTGAACAGGCGACCATGCTTTTCAGCTCTGGAAAGTGGATGAAACATACGTTCCCAAGAGTTTAACTGCTGAAACATT
L V N R R P C F S A L E V D E T Y V P K E F N A E T F

1530 1540 1550 1560 1570 1580 1590 1600
CACCTTCCATGCAGATATATGCACACTTTCTGAGAAAGGAGAGACAAATCAAGAAACAAAAGTGCCTTGTGAGCTTGTGA
T F H A D I C T L S E K E R Q I K K Q T A L V E L V

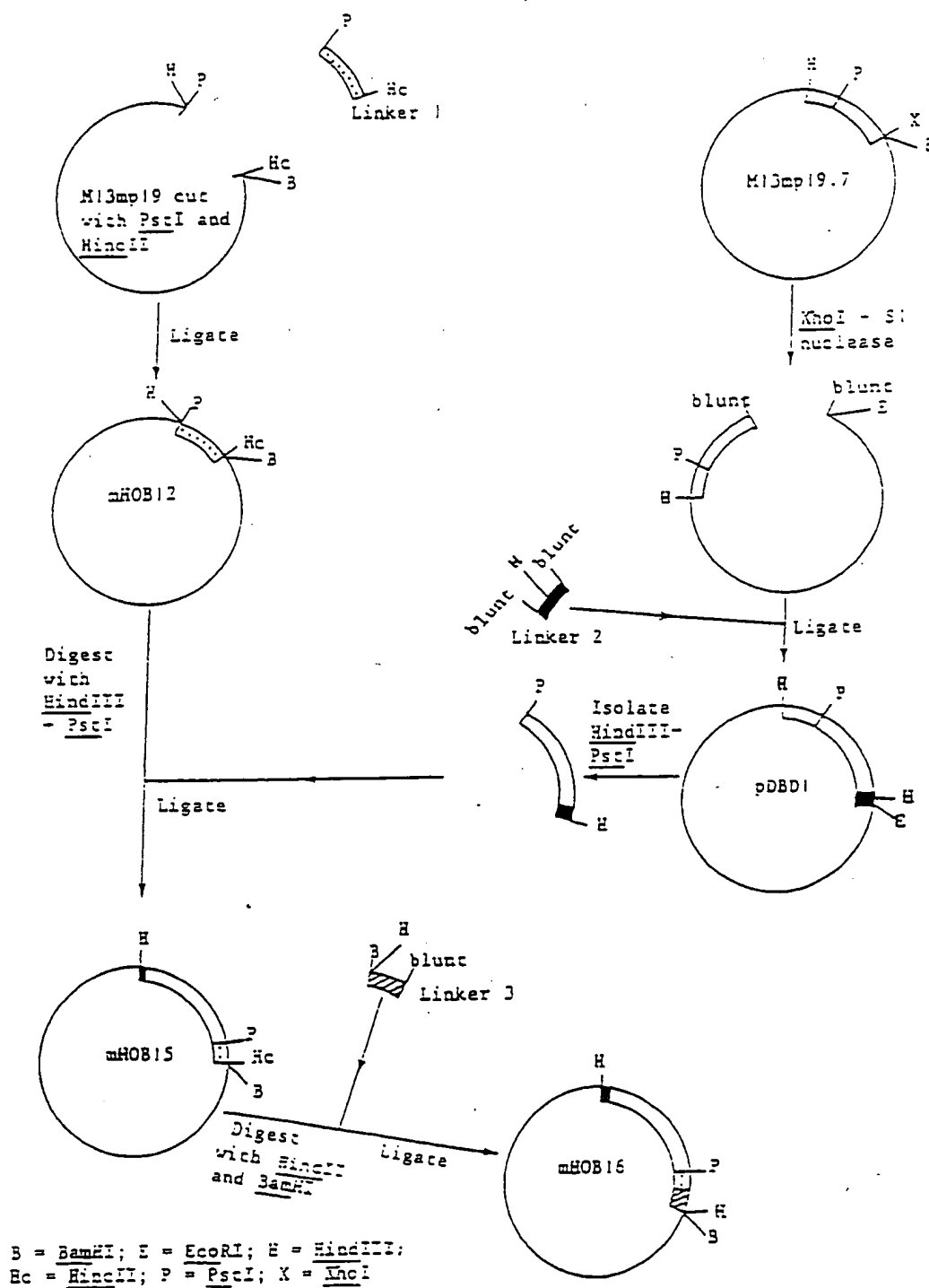
1610 1620 1630 1640 1650 1660 1670 1680
AACACAAGCCCAAGGCAACAAAAGAGCAACTGAAAGCTGTTATGGATGATTTCCGAGCTTTTGTAGAGAAAGTCTGCAAG
K H K P K A T K E Q L K A V M D D F A A F V E K C C K

1690 1700 1710 1720 1730 1740 1750 1760
GCTGACGATAAGGAGACCTGCTTTGCCGAGGAGGGTAAAAAACTTGTGCTGCAAGTCAAGCTGCCCTTAGGCTTATAACA
A D D K E T C F A E E G K K L V A A S Q A A L G L

1770 1780
TCTACATTTAAAAGCATCTCAG

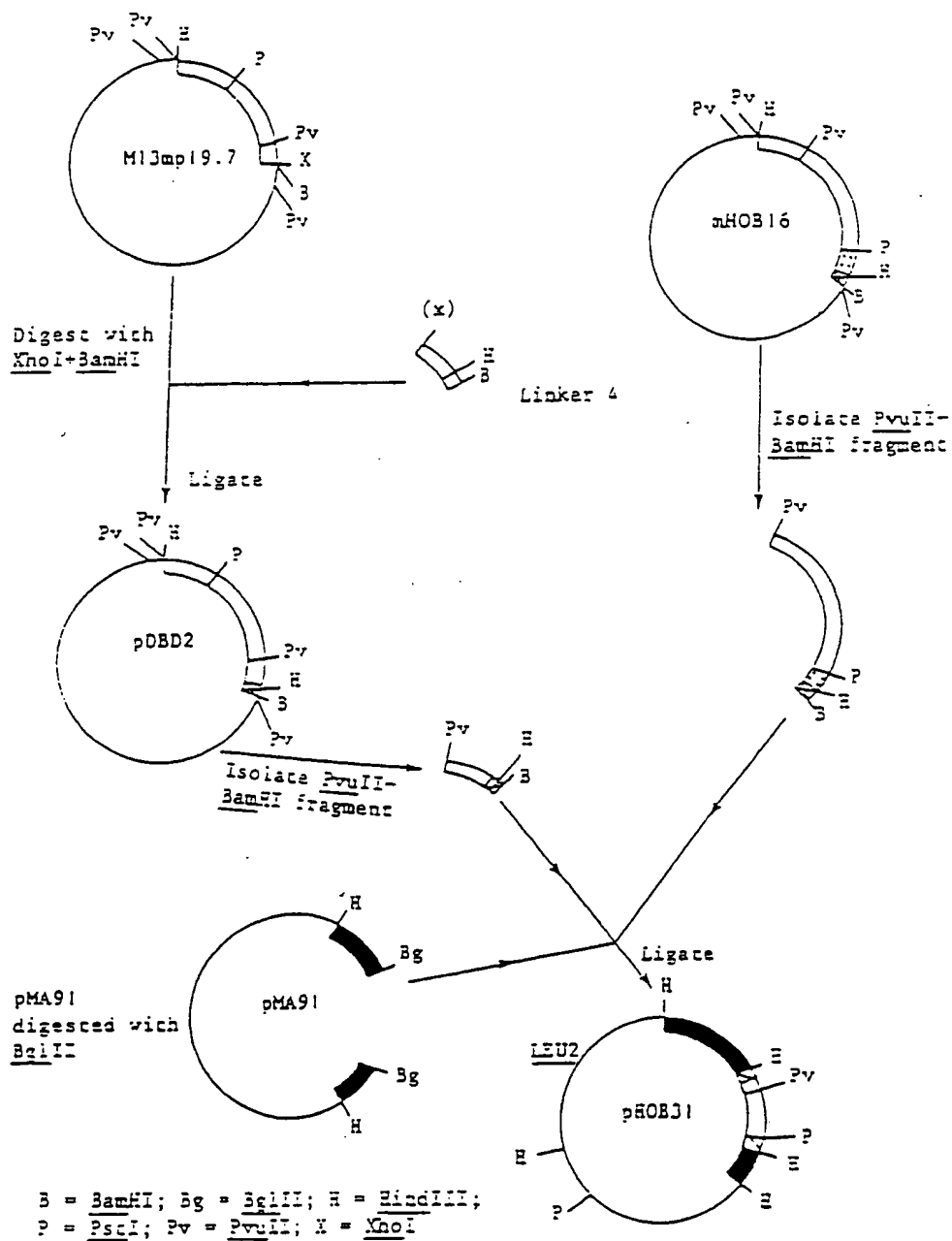
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FIGURE 3 Construction of mHOB16



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FIGURE 1 Construction of pROB31



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Fig. 5A

10 Gln Ala Gln Met Val Gln Pro Gln Ser Pro Val Ala Val Ser Gln Ser Lys Pro Gly
 20 Cys Tyr Asp Asn Gly Lys His Tyr Gln Ile Asn Gln Gln Trp Glu Arg Thr Tyr Leu Gly
 30 Asn Val Leu Val Cys Thr Cys Tyr Gly Gly Ser Arg Gly Phe Asn Cys Glu Ser Lys Pro
 40 Glu Ala Glu Glu Thr Cys Phe Asp Lys Tyr Thr Gly Asn Thr Tyr Arg Val Gly Asp Thr
 50 Tyr Glu Arg Pro Lys Asp Ser Met Ile Trp Asp Cys Thr Cys Ile Gly Ala Gly Arg Gly
 60 Arg Ile Ser Cys Thr Ile Ala Asn Arg Cys His Glu Gly Gly Gln Ser Tyr Lys Ile Gly
 70 Asp Thr Trp Arg Arg Pro His Glu Thr Gly Tyr Met Leu Glu Cys Val Cys Leu Gly
 80 Asn Gly Lys Gly Glu Trp Thr Cys Lys Pro Ile Ala Glu Lys Cys Phe Asp His Ala Ala
 90 Gly Thr Ser Tyr Val Val Gly Glu Thr Trp Glu Lys Pro Tyr Gln Gly Trp Met Met Val
 100 Asp Cys Thr Cys Leu Gly Glu Gly Ser Gly Arg Ile Thr Cys Thr Ser Arg Asn Arg Cys
 110 Asn Asp Gln Asp Thr Arg Thr Ser Tyr Arg Ile Gly Asp Thr Trp Ser Lys Lys Asp Asn
 120 Arg Gly Asn Leu Leu Gln Cys Ile Cys Thr Gly Asn Gly Arg Gly Glu Trp Lys Cys
 130 Arg His Thr Ser Val Gln Thr Thr Ser Ser Gly Ser Gly Pro Phe Thr Asp Val Arg Ala
 140 Ala Val Tyr Gln Pro Gln Pro His Pro Gln Pro Pro Tyr Gly His Cys Val Thr Asp
 150 Ser Ely Val Val Tyr Ser Val Gly Met Gly Trp Leu Lys Thr Gln Gly Asn Lys Gln Met
 160 Leu Cys Thr Cys Leu Gly Asn Gly Val Ser Cys Gln Glu Thr Ala Val Thr Gln Thr
 170 Gly Gly Asn Ser Asn Gly Glu Pro Cys Val Leu Pro Phe Thr Tyr Asn Gly Arg Thr
 180 Tyr Ser Cys Thr Thr Glu Gly Arg Gln Asp Gly His Leu Trp Cys Ser Thr Ser
 190 Tyr Glu Gln Asp Gln Lys Tyr Ser Phe Cys Thr Asp His Thr Val Leu Val Gln Thr
 200 Gly Gly Asn Ser Asn Ely Ala Leu Cys His Phe Pro Phe Leu Tyr Asn Asn His Tyr
 210 Thr Asp Cys Thr Ser Glu Gly Arg Arg Asp Asn Met Lys Trp Cys Gly Thr Thr Gln Asn

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Fig. 5B

Tyr Asp Ala Asp Gln Lys Phe Gly Phe Cys⁴³⁰ Pro Met Ala Ala His Glu Glu Ile Cys⁴⁴⁰ Thr
 Thr Asn Glu Gly Val Met Tyr Arg Ile Gly⁴⁵⁰ Asp Gln Trp Asp Lys Gln His Asp Met Gly⁴⁶⁰
 His Met Met Arg Cys Thr Cys Val Gly Asn Gly Arg Gly Glu Trp Thr Cys Tyr Ala Tyr⁴⁸⁰
 Ser Gln Leu Arg Asp Gln Cys Ile Val Asp⁴⁹⁰ Asp Ile Thr Tyr Asn Val Asn Asp Thr Phe⁵⁰⁰
 His Lys Arg His Glu Glu Gly His Met Leu Asn Cys Thr Cys Phe Gly Gln Gly Arg Gly⁵²⁰
 Arg Trp Lys Cys Asp Pro Val Asp Gln Cys Gln Asp Ser Glu Thr Gly Thr Phe Tyr⁵⁴⁰ Gln
 Ile Gly Asp Ser Trp Glu Lys Tyr Val His⁵⁵⁰ Gly Val Arg Tyr Gln Cys Tyr Cys Tyr⁵⁶⁰ Gly
 Arg Gly Ile Gly Glu Trp His Cys Gln Pro⁵⁷⁰ Leu Gln Thr Tyr Fro Ser Ser Ser Gly⁵⁸⁰ Pro
 Val Glu Val Phe Ile Thr Glu Thr Pro Ser Gln Pro Asn Ser His Pro Ile Gln Trp Asn⁶⁰⁰
 Ala Pro Gln Pro Ser His Ile Ser Lys Tyr⁶¹⁰ Ile Leu Arg Trp Arg Pro Lys Asn Ser Val⁶²⁰
 Gly Arg Trp Lys Glu Ala Thr Ile Pro Gly⁶³⁰ His Leu Asn Ser Tyr Thr Ile Lys Gly Leu⁶⁴⁰
 Lys Pro Gly Val Val Tyr Glu Gly Glr Leu⁶⁵⁰ Ile Ser Ile Gln Gln Tyr Gly His Gln Glu⁶⁶⁰
 Val Thr Arg Phe Asp Phe Thr Thr Thr Ser⁶⁷⁰ Thr Ser Thr Pro Val Thr Ser Asn Thr Val⁶⁸⁰
 Thr Gly Glu Thr Thr Pro Phe Ser Pro⁶⁹⁰ Leu Val Ala Thr Ser Glu Ser Val Thr Glu Ile⁷⁰⁰
 Thr Ala Ser Ser Phe Val Val Ser Trp Val⁷¹⁰ Ser Ala Ser Asp Thr Val Ser Gly Phe Arg⁷²⁰
 Val Glu Tyr Glu Leu Ser Glu Glu Gly Asp⁷³⁰ Glu Pro Gln Tyr Leu Asp Leu Pro Ser Thr⁷⁴⁰
 Ala Thr Ser Val Asn Ile Pro Asp Leu Leu⁷⁵⁰ Pro Ely Arg Lys Tyr Ile Val Asn Val Tyr⁷⁶⁰
 Gln Ile Ser Glu Asp Gly Glu Gln Ser Leu⁷⁷⁰ Ile Leu Ser Thr Ser Gln Thr Thr Ala Pro⁷⁸⁰
 Asp Ala Pro Pro Asp Pro Thr Val Asp⁷⁹⁰ Gln Val Asp Asp Thr Ser Ile Val Val Arg Trp⁸⁰⁰
 Ser Arg Pro Glr Ala Pro Ile Thr Gly⁸¹⁰ Tyr Arg Ile Val Tyr Ser Pro Ser Val Glu Gly⁸²⁰
 Ser Ser Thr Glu Leu Asn Leu Pro Glu Thr⁸³⁰ Ala Asn Ser Val Thr Leu Ser Asp Leu Gln⁸⁴⁰

FNDEL 1

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Fig. 5C

850 Pro Gly Val Gln Tyr Asn Ile Thr Ile Tyr Ala Val Glu Glu Asn Gln Glu Ser Thr 860 Pro
 870 Val Val Ile Gln Gln Glu Thr Thr Gly Thr Pro Arg Ser Asp Thr Val Pro Ser Pro Arg 880
 890 Aso Leu Gln Phe Val Glu Val Thr Asp Val Lys Val Thr Ile Met Trp Thr Pro Pro Glu 900
 910 Ser Ala Val Thr Gly Tyr Arg Val Asp Val Ile Pro Val Asn Leu Pro Gly Glu His Gly 920
 930 Gln Arg Leu Pro Ile Ser Arg Asn Thr Phe Ala Glu Val Thr Gly Leu Ser Pro Gly Val 940
 950 Thr Tyr Tyr Phe Lys Val Phe Ala Val Ser His Gly Arg Glu Ser Lys Pro Leu Thr Ala 960
 970 Gln Gln Thr Thr Lys Leu Asp Ala Pro Thr Asn Leu Gln Phe Val Asn Glu Thr Asp Ser 980
 990 Thr Val Leu Val Arg Trp Thr Pro Pro Arg Ala Gln Ile Thr Gly Tyr Arg Leu Thr Val 1000
 1010 Gly Leu Thr Arg Arg Gly Gln Pro Arg Gln Tyr Asn Val Gly Pro Ser Val Ser Lys Tyr 1020
 1030 Pro Leu Arg Asn Leu Gln Pro Ala Ser Glu Tyr Thr Val Ser Leu Val Ala Ile Lys Gly 1040
 1050 Asn Gln Glu Ser Pro Lys Ala Thr Gly Val Phe Thr Thr Leu Gln Pro Gly Ser Ser Ile 1060
 1070 Pro Pro Tyr Asn Thr Glu Val Thr Glu Thr Thr Ile Val Ile Thr Trp Thr Pro Ala Pro 1080
 1090 Arg Ile Gly Phe Lys Leu Gly Val Arg Pro Ser Gln Gly Gly Glu Ala Pro Arg Glu Val 1100
 1110 Thr Ser Asp Ser Gly Ser Ile Val Val Ser Gly Leu Thr Thr Pro Gly Val Glu Tyr Val Tyr 1120
 1130 Thr Ile Gln Val Leu Arg Asp Gly Gln Glu Arg Asp Ala Pro Ile Val Asn Lys Val Val 1140
 1150 Thr Pro Leu Ser Pro Pro Thr Asn Leu His Leu Glu Ala Asn Pro Asp Thr Gly Val Leu 1160
 1170 Thr Val Ser Trp Glu Arg Ser Thr Thr Pro Asp Ile Thr Gly Tyr Arg Ile Thr Thr Thr 1180
 1190 Pro Thr Asn Gly Gln Gln Gly Asn Ser Leu Glu Glu Val Val His Ala Asp Gln Ser Ser 1200
 1210 Cys Thr Phe Asp Asn Leu Ser Pro Gly Leu Glu Tyr Asn Val Ser Val Tyr Thr Val Lys 1220
 1230 Asp Asp Lys Glu Ser Val Pro Ile Ser Asp Thr Ile Ile Pro Ala Val Pro Pro Thr 1240
 1250 Asp Leu Arg Phe Thr Asn Ile Gly Pro Asp Thr Met Arg Val Thr Trp Ala Pro Pro Pro 1260

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Fig. 5D

Ser Ile Asp Leu Thr Asn Phe Leu Val Arg Tyr Ser Pro Val Lys Asn Glu Glu Asp Val
 Ala Glu Leu Ser Ile Ser Pro Ser Asp Asn Ala Val Val Leu Thr Asn Leu Leu Pro Gly
 Thr Glu Tyr Val Val Ser Val Ser Val Tyr Glu Gln His Glu Ser Thr Pro Leu Arg
 Gly Arg Gln Lys Thr Gly Leu Asp Ser Pro Thr Gly Ile Asp Phe Ser Asp Ile Thr Ala
 Asn Ser Phe Thr Val His Trp Ile Ala Pro Arg Ala Thr Ile Thr Gly Tyr Arg Ile Arg
 His His Pro Glu His Phe Ser Gly Arg Pro Arg Glu Asp Arg Val Pro His Ser Arg Asn
 Ser Ile Thr Leu Thr Asn Leu Thr Pro Gly Thr Glu Tyr Val Val Ser Ile Val Ala Leu
 Asn Gly Arg Glu Glu Ser Pro Leu Leu Ile Gly Gln Gln Ser Thr Val Ser Asp Val Pro
 Arg Asp Leu Glu Val Val Ala Ala Thr Pro Thr Ser Leu Leu Ile Ser Trp Asp Ala Pro
 Ala Val Thr Val Arg Tyr Tyr Arg Ile Thr Tyr Gly Glu Thr Gly Gly Asn Ser Pro Val
 Gln Glu Phe Thr Val Pro Gly Ser Lys Ser Thr Ala Thr Ile Ser Gly Leu Lys Pro Gly
 Val Asp Tyr Thr Ile Thr Val Tyr Ala Val Thr Gly Arg Gly Asp Ser Pro Ala Ser Ser
 Lys Pro Ile Ser Ile Asn Tyr Arg Thr Glu Ile Asp Lys Pro Ser Gln Met Gln Val Thr
 Asp Val Gln Asp Asn Ser Ile Ser Val Lys Trp Leu Pro Ser Ser Ser Pro Val Thr Gly
 Tyr Arg Val Thr Thr Thr Pro Lys Asn Gly Pro Gly Pro Thr Lys Thr Lys Thr Ala Gly
 Pro Asp Gln Thr Glu Met Thr Ile Glu Gly Leu Gln Pro Thr Val Glu Tyr Val Val Ser
 Val Tyr Ala Gln Asn Pro Ser Gly Glu Ser Gln Pro Leu Val Gln Thr Ala Val Thr Thr
 Ile Pro Ala Pro Thr Asp Leu Lys Phe Thr Gln Val Thr Pro Thr Ser Leu Ser Ala Gln
 Trp Thr Pro Pro Asn Val Gln Leu Thr Gly Tyr Arg Val Arg Val Thr pro Lys Glu Lys
 Thr Gly Pro Met Lys Glu Ile Asn Leu Ala Pro Asp Ser Ser Val Val Val Ser Gly
 Leu Met Val Ala Thr Lys Tyr Glu Val Ser Val Tyr Ala Leu Lys Asp Thr Leu Thr Ser
 FNDEL I

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Fig. 5E

Arg	Pro	Ala	Gln	Gly	Val	Thr	Thr	Leu	Glu	Asn	Val	Ser	Pro	Pro	Arg	Arg	Ala	Arg	1690	1700
Val	Thr	Asp	Ala	Thr	Glu	Thr	Thr	Ile	Ser	Trp	Arg	Thr	Lys	Thr	Glu	Thr	Ile	1710	1720	
Thr	Gly	Phe	Gln	Val	Asp	Ala	Val	Pro	Ala	Asn	Gly	Gln	Thr	Pro	Ile	Gln	Arg	Thr	1730	1740
Lys	Pro	Asp	Val	Arg	Ser	Tyr	Thr	Ile	Thr	Gly	Leu	Gln	Pro	Gly	Thr	Asp	Tyr	Lys	1750	1760
Tyr	Leu	Tyr	Thr	Lau	Asn	Asp	Ala	Arg	1770	Ser	Ser	Pro	Val	Val	Ile	Asp	Ala	Ser	1780	1790
Ala	Ile	Asp	Ala	Pro	Ser	Asn	Lau	Arg	Phe	Lau	Ala	Thr	Thr	Pro	Asn	Ser	Leu	Leu	1800	1810
Ser	Trp	Gln	Pro	Pro	Arg	Ala	Arg	Ile	Thr	Gly	Tyr	Ile	Ile	Lys	Tyr	Glu	Lys	Pro	1820	1830
Ser	Pro	Pro	Arg	Glu	Val	Val	Pro	Arg	Pro	Arg	Pro	Gly	Val	Thr	Glu	Ala	Thr	Ile	1840	1850
Gly	Leu	Glu	Pro	Gly	Thr	Glu	Tyr	Thr	Ile	Tyr	Val	Ile	Ala	Leu	Lys	Asn	Gln	Lys	1860	1870
Ser	Glu	Pro	Leu	Ile	Gly	Arg	Lys	Lys	Thr	Aso	Glu	Leu	Pro	Gln	Leu	Val	Thr	Leu	1880	1890
His	Pro	Asn	Leu	His	Gly	Pro	Glu	Ile	Leu	Asp	Val	Pro	Ser	Thr	Val	Gln	Lys	Thr	1900	1910
Phe	Val	Thr	His	Pro	Gly	Tyr	Asp	Thr	Gly	Asn	Gly	Ile	Gln	Leu	Pro	Gly	Thr	Ser	1920	1930
Gln	Gln	Pro	Ser	Val	Gly	Gln	Gln	Met	Ile	Phe	Glu	Glu	His	Gly	Phe	Arg	Arg	Thr	1940	1950
Pro	Pro	Thr	Thr	Ala	Thr	Pro	Ile	Arg	His	Arg	Pro	Arg	Pro	Tyr	Pro	Pro	Asn	Val	1960	1970
Leu	Ser	Gln	Thr	Thr	Ile	Ser	Trp	Ala	Pro	Phe	Gln	Aso	Thr	Ser	Glu	Tyr	Ile	Ile	1980	1990
Cys	His	Pro	Val	Gly	Thr	Asp	Glu	Glu	Pro	Leu	Gln	Phe	Arg	Val	Pro	Gly	Thr	Ser	2000	2010
Ser	Ala	Thr	Leu	Thr	Gly	Leu	Thr	Arg	Gly	Ala	Thr	Tyr	Asn	Ile	Ile	Val	Glu	Ala	2020	2030
Lys	Asp	Gln	Gln	Arg	His	Lys	Val	Arg	Leu	Val	Thr	Val	Gly	Asn	Ser	Val	Asn	2040	2050	
Glu	Gly	Leu	Asn	Gln	Pro	Thr	Asp	Asp	Ser	Cys	Phe	Asp	Pro	Tyr	Thr	Val	Ser	His	2060	2070
Ala	Val	Gly	Asp	Glu	Trp	Glu	Arg	Met	Ser	Glu	Ser	Gly	Phe	Lys	Leu	Leu	Cys	Gln	2080	2090
Leu	Ser	Phe	Gly	Ser	Gly	His	Phe	Arg	Cys	Asp	Ser	Ser	Arg	Trp	Cys	His	Asp	Asn	2100	2110

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Val	Asn	Tyr	Lys	Ile	Gly	Glu	Lys	Trp	Asp	Arg	Gln	Gly	Glu	Asn	Gly	Gln	Met	Met	Ser	2120
Cys	Thr	Cys	Leu	Gly	Asn	Gly	Lys	Gly	Glu	Phe	Lys	Cys	Asp	Pro	His	Glu	Ala	Thr	Cys	2140
Tyr	Asp	Asp	Gly	Lys	Thr	Tyr	His	Val	Gly	Glu	Gln	Trp	Gln	Lys	Glu	Tyr	Leu	Gly	Ala	2160
Ile	Cys	Ser	Cys	Thr	Cys	Phe	Gly	Gly	Gln	Arg	Gly	Trp	Arg	Cys	Asp	Asn	Cys	Arg	Arg	2180
Pro	Gly	Gly	Glu	Pro	Ser	Pro	Glu	Gly	Thr	Thr	Gly	Gln	Ser	Tyr	Asn	Gln	Tyr	Ser	Gln	2200
Arg	Tyr	His	Gln	Arg	Thr	Asn	Thr	Asn	Val	Asn	Cys	Pro	Ile	Glu	Cys	Phe	Met	Pro	Leu	2220
Asp	Val	Gln	Ala	Asp	Arg	Glu	Asp	Ser	Arg	Glu										2230

Fig. 5F

SEQUENCE SHEET

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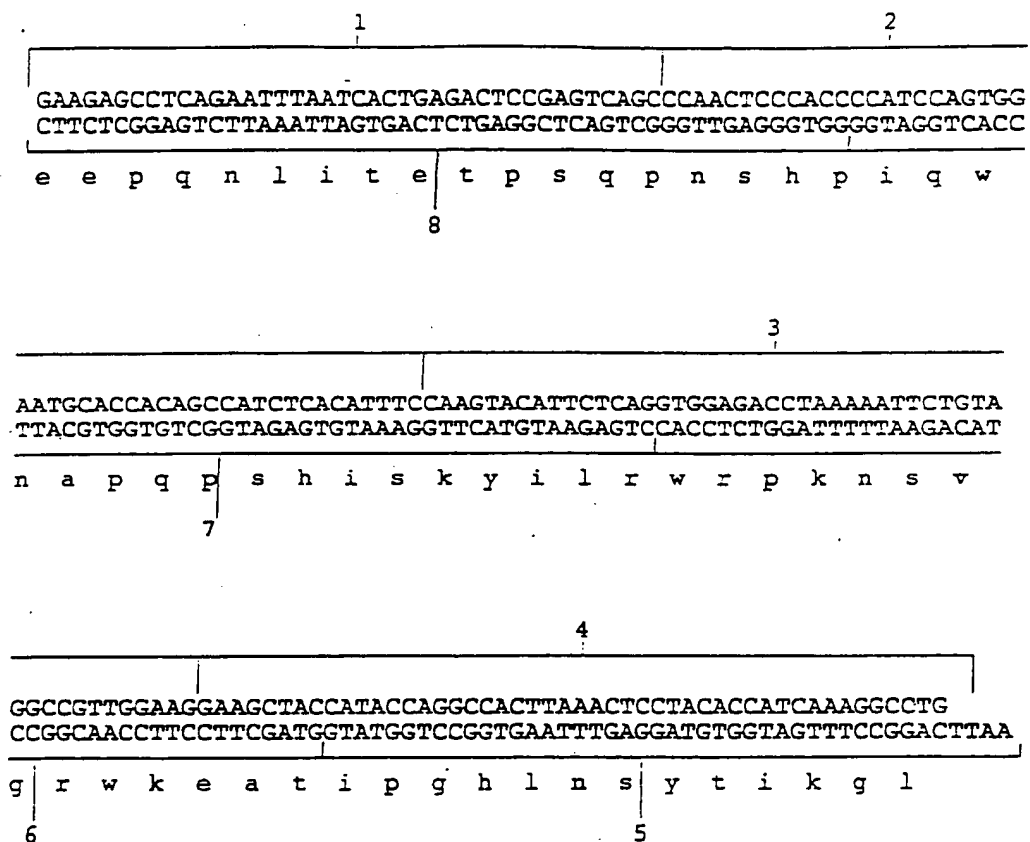


Figure 6 Linker 5 showing the eight constituent oligonucleotides

SUPPLEMENT SHEET

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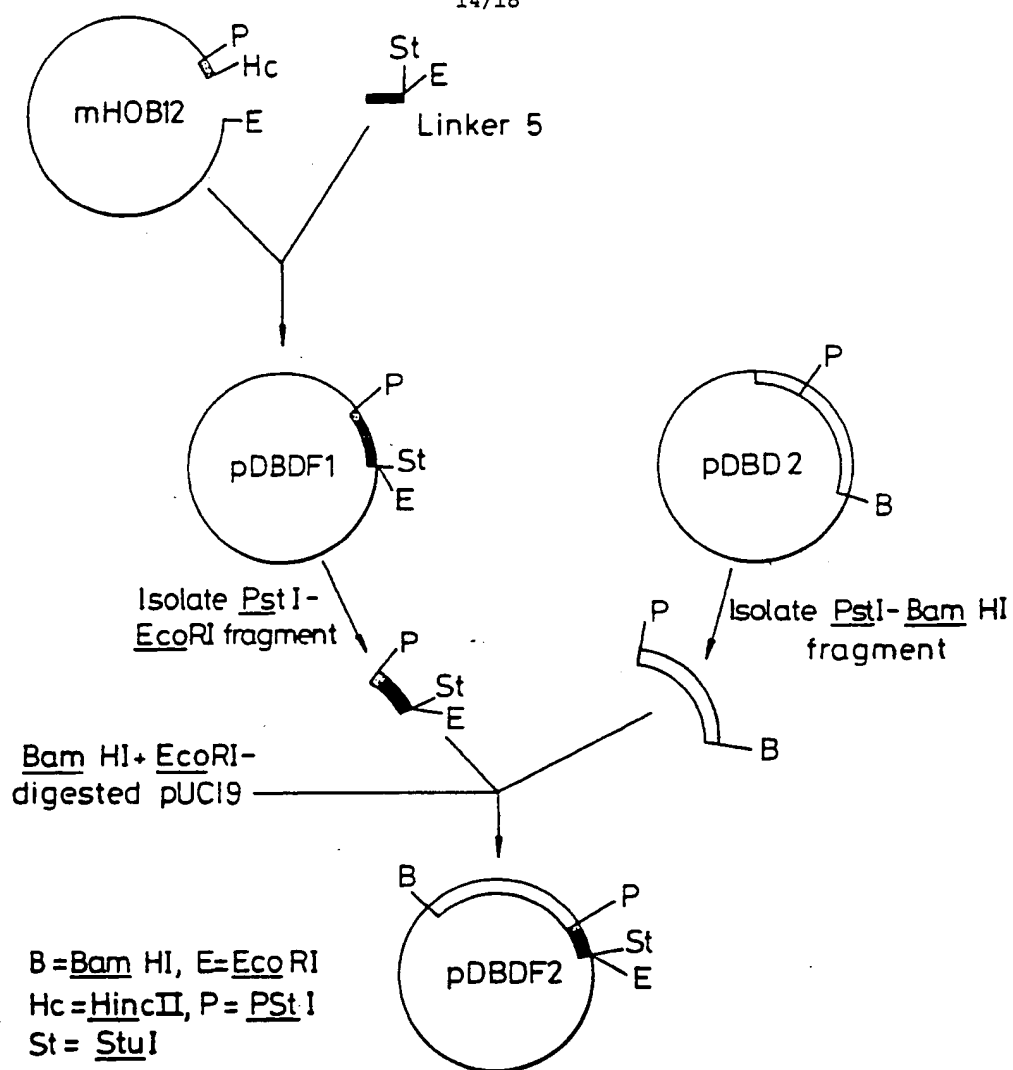


Fig. 7 Construction of pDBDF2

SUPPLEMENTARY SHEET

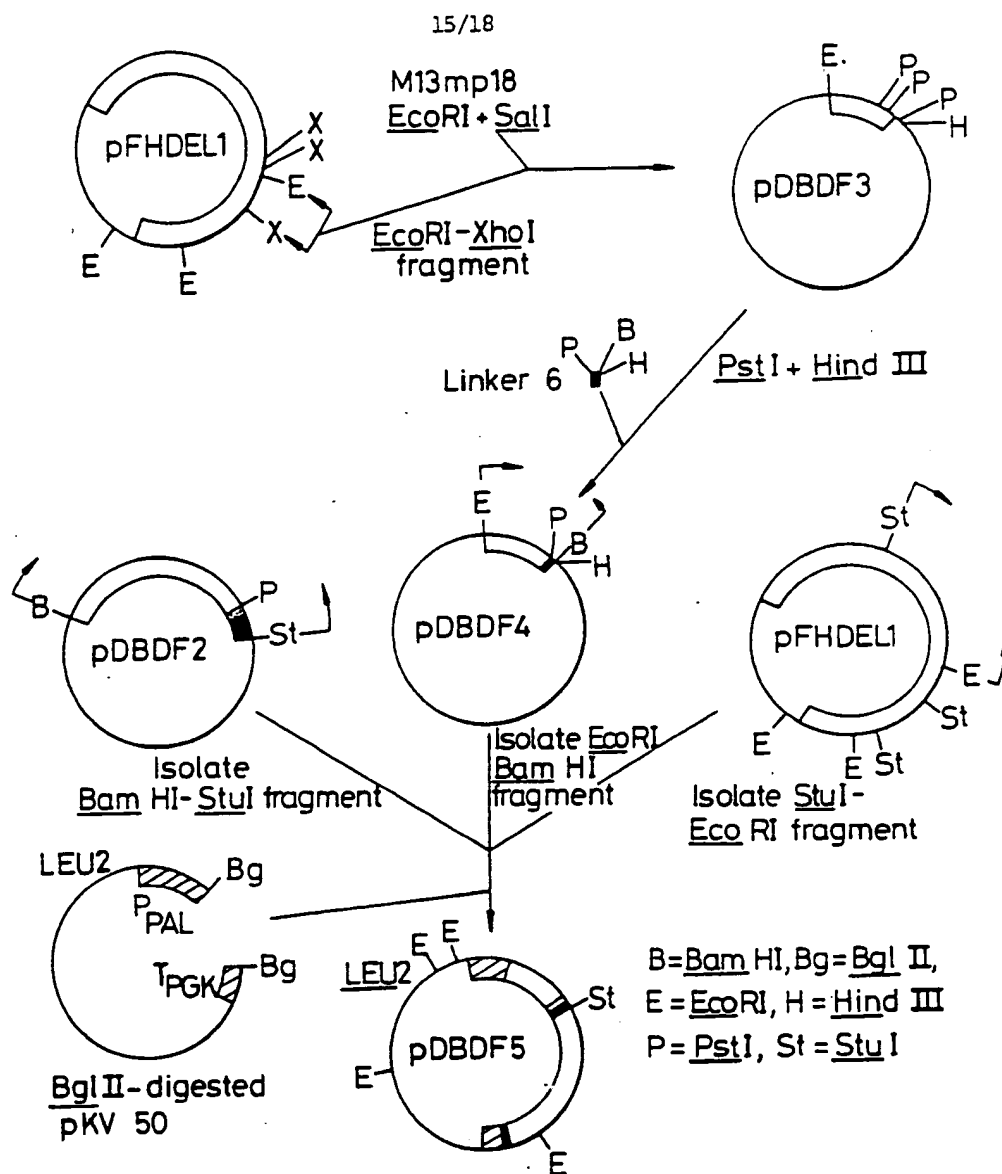


Fig. 8 Construction of pDBDF5

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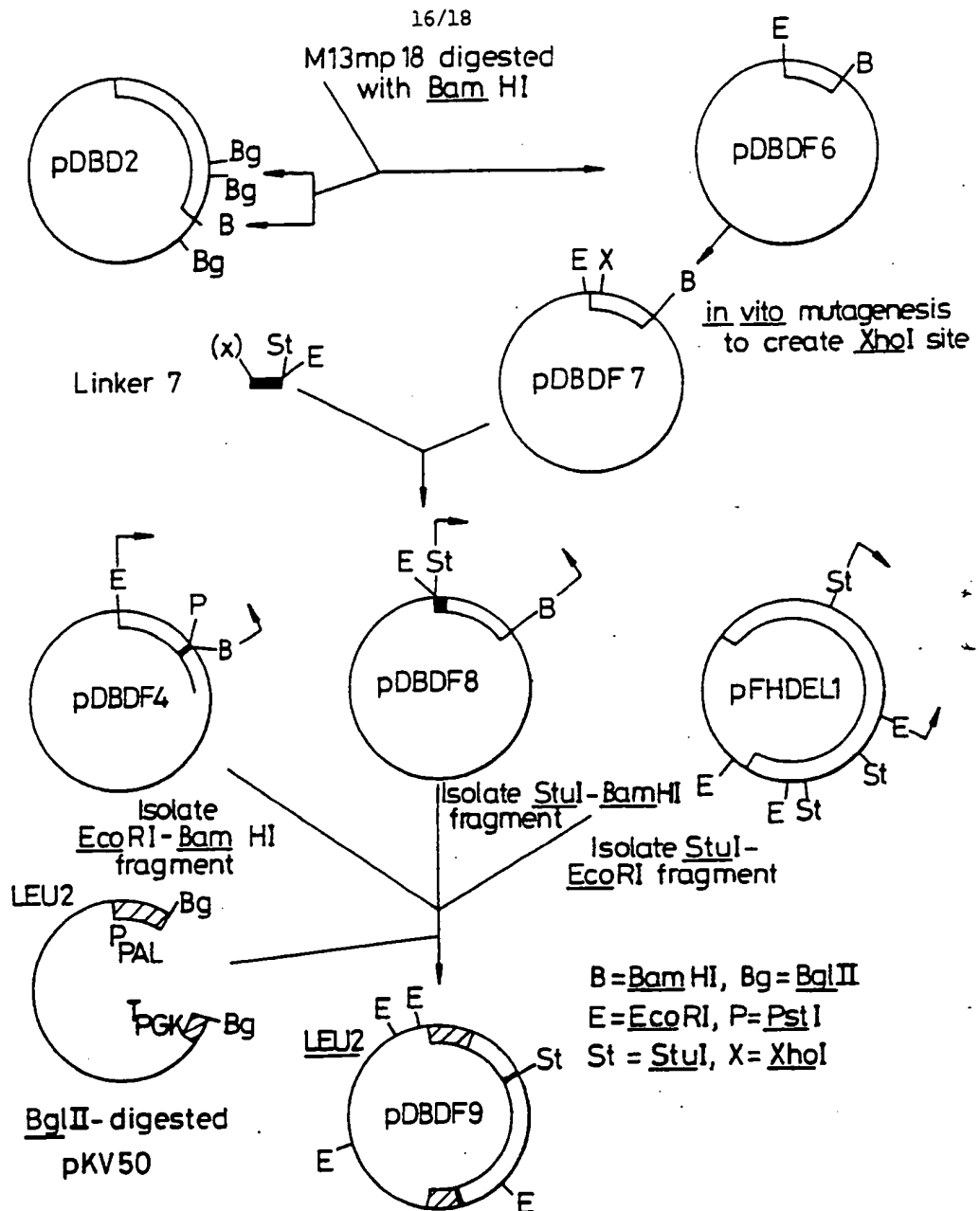


Fig. 9 Construction of pDBDF9

SUPPLEMENTARY SHEET

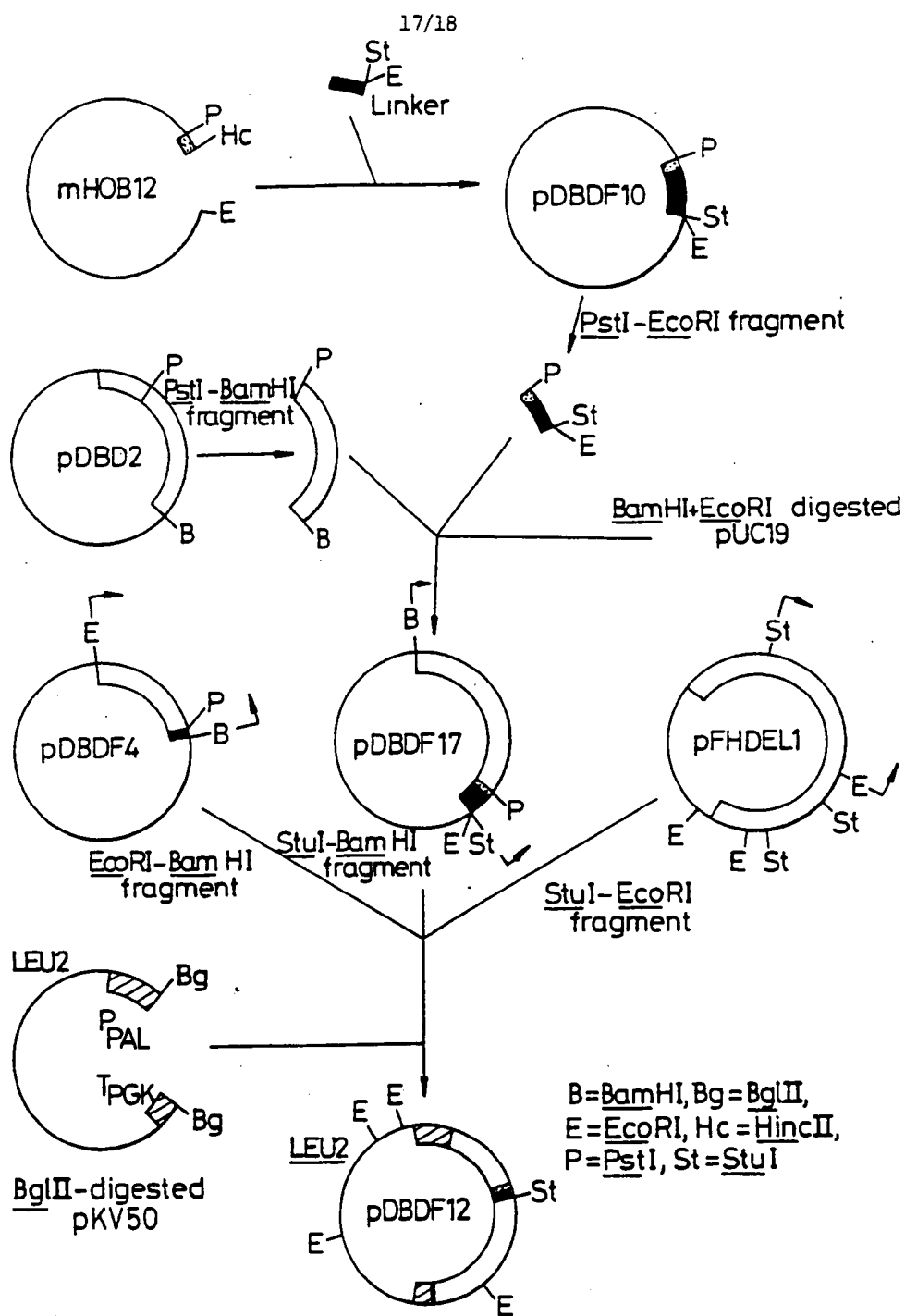
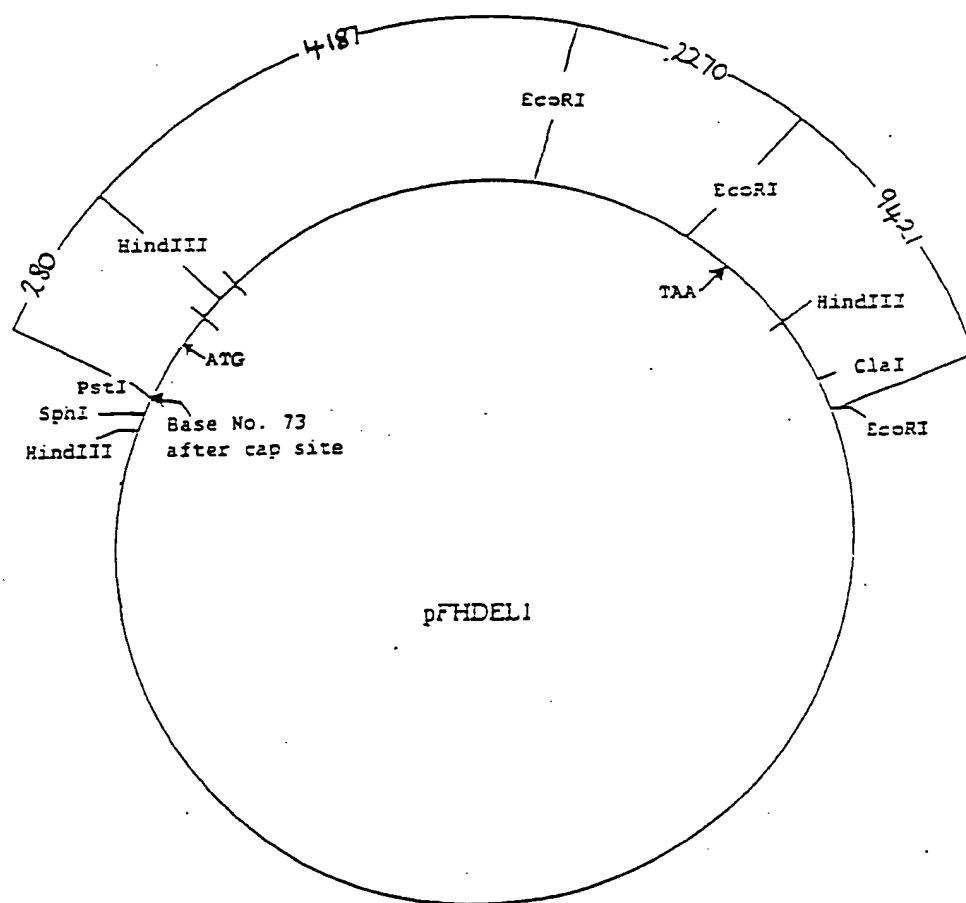


Fig. 10 Construction of pDBDF12

Figure 11

Name: pFHDEL1
Vector: pUC18 Amp^r 2860bp
Insert: hFNCdNA - 7630bp



SUBSTITUTE SHEET

INTERNATIONAL SEARCH REPORT

International Application No. PCT/GB 90/00650

I. CLASSIFICATION OF SUBJECT MATTER (If several classification symbols apply, indicate all) * According to International Patent Classification (IPC) or to both National Classification and IPC IPC ⁵ : C 12 N 15/62, C 07 K 13/00, C 12 P 21/02																	
II. FIELDS SEARCHED Minimum Documentation Searched * Classification System Classification Symbols IPC ⁵ C 12 N, C 12 P, C 07 K Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched *																	
III. DOCUMENTS CONSIDERED TO BE RELEVANT <table border="1"> <thead> <tr> <th>Category *</th> <th>Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²</th> <th>Relevant to Claim No. ¹³</th> </tr> </thead> <tbody> <tr> <td>A</td> <td>EP, A, 0308381 (SKANDIGEN et al.) 22 March 1989</td> <td></td> </tr> <tr> <td></td> <td>---</td> <td></td> </tr> <tr> <td>T</td> <td>EP, A, 0322094 (DELTA BIOTECHNOLOGY LTD) 28 June 1989 (cited in the application)</td> <td></td> </tr> <tr> <td></td> <td>-----</td> <td></td> </tr> </tbody> </table>			Category *	Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No. ¹³	A	EP, A, 0308381 (SKANDIGEN et al.) 22 March 1989			---		T	EP, A, 0322094 (DELTA BIOTECHNOLOGY LTD) 28 June 1989 (cited in the application)			-----	
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<p>* Special categories of cited documents: ¹⁴</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> <p>"T" later document published after the international filing date of priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>"A" document member of the same patent family</p>																	
IV. CERTIFICATION <table border="1"> <tr> <td>Date of the Actual Completion of the International Search</td> <td>Date of Mailing of this International Search Report</td> </tr> <tr> <td>10th July 1990</td> <td>09. 08. 90</td> </tr> <tr> <td>International Searching Authority</td> <td>Signature of Authorized Officer</td> </tr> <tr> <td>EUROPEAN PATENT OFFICE</td> <td>M. SOTELO</td> </tr> </table>			Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report	10th July 1990	09. 08. 90	International Searching Authority	Signature of Authorized Officer	EUROPEAN PATENT OFFICE	M. SOTELO							
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**ANNEX TO THE INTERNATIONAL SEARCH REPORT
ON INTERNATIONAL PATENT APPLICATION NO.**

GB 9000650
SA 36670

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The members are as contained in the European Patent Office EDP file on 31/07/90
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP-A- 0308381	22-03-89	SE-B- 459586	17-07-89
		AU-A- 2420488	17-04-89
		SE-A- 8703539	15-03-89
		WO-A- 8902467	23-03-89
EP-A- 0322094	28-06-89	AU-A- 2404688	18-05-89

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